Nuclear Fuel Cycle Technologies: Current Challenges and Future Plans - 12558

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ABSTRACT

The mission of the Office of Nuclear Energy's Fuel Cycle Technologies office (FCT program) is to provide options for possible future changes in national nuclear energy programs. While the recent draft report of the Blue Ribbon Commission on America's Nuclear Future stressed the need for organization changes, interim waste storage and the establishment of a permanent repository for nuclear waste management, it also recognized the potential value of alternate fuel cycles and recommended continued research and development in that area. With constrained budgets and great expectations, the current challenges are significant. The FCT program now performs R&D covering the entire fuel cycle. This broad R&D scope is a result of the assignment of new research and development (R&D) responsibilities to the Office of Nuclear Energy (NE), as well as reorganization within NE. This scope includes uranium extraction from seawater and uranium enrichment R&D, used nuclear fuel recycling technology, advanced fuel development, and a fresh look at a range of disposal geologies. Additionally, the FCT program performs the necessary systems analysis and screening of fuel cycle alternatives that will identify the most promising approaches and areas of technology gaps. Finally, the FCT program is responsible for a focused effort to consider features of fuel cycle technology in a way that promotes nonproliferation and security, such as Safeguards and Security by Design, and advanced monitoring and predictive modeling capabilities. This paper and presentation will provide an overview of the FCT program R&D scope and discuss plans to analyze fuel cycle options and support identified R&D priorities into the future.

INTRODUCTION

U.S. nuclear policy and the nuclear industry are in a dynamic period. Recent events that include the establishment of the Blue Ribbon Commission on America's Nuclear Future and the plant behavior at the Fukushima Dai-ichi Nuclear Power Station have all contributed to a need for a fresh view of the various fuel cycle options that are best for the U.S.

With the issuance of the Nuclear Energy Research and Development Roadmap in April 2010[1], the Department of Energy's (DOE) Office of Nuclear Energy started a fresh view by making development of a sustainable fuel cycle one of the four objectives of the

[1] http://nuclear.energy.gov/pdfFiles/NuclearEnergy_Roadmap_Final.pdf

roadmap. The Office of Fuel Cycle Technologies, within the Office of Nuclear Energy, has responsibility for defining and evaluating the options and technologies for the possible future implementation of a sustainable fuel cycle in the U.S. Also, in response to the events at Fukushima Dai-ichi, there are near term alternative fuel concepts for light water reactors that may enhance the ability to withstand extreme conditions caused under accident conditions.

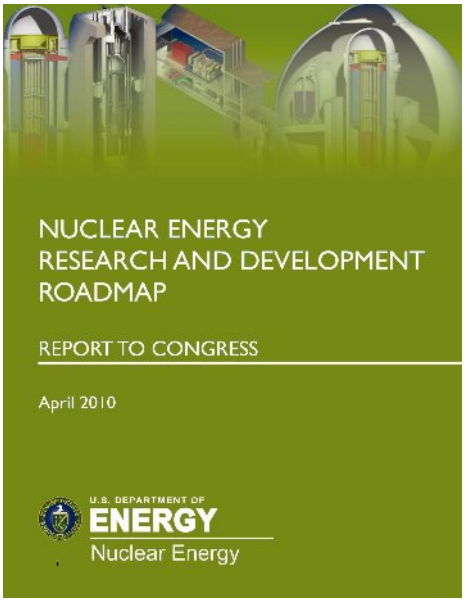

Figure 1 The Nuclear Energy Research and Development Roadmap established a science based engineering oriented fuel cycle R&D program.

The recent reorganization of the Office of Nuclear Energy has also strengthened the FCT program's abilities by adding the Uranium Management and Policy function to the already existing systems analysis, advanced fuel, separations and waste forms, and used fuel disposition functions. The used fuel disposition research and development function was added when the Office of Civilian Radioactive Waste Management was dissolved. These functions together provide an integrated look at the broad spectrum of fuel cycle alternatives available for development and evaluation. It is recognized that these fuel cycle technologies and alternatives require integration with specific reactor designs and concepts. It is also recognized that the U.S. nuclear policy and nuclear industry market will ultimately choose the fuel cycle of the future.

RECENT EVENTS

Recent events have shaped the context of the Office of Fuel Cycle Technologies focus in different ways. The following sections provide a discussion of this context.

Blue Ribbon Commission

Established in January of 2010, the 15-member Blue Ribbon Commission (BRC) was chartered to conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle and recommend a new plan[2]. The BRC held public hearings in Washington, DC, and across the country, to take input from technical and policy experts, elected officials, community leaders, environmental organizations and other interested parties. In additional, the BRC established three subcommittees to specifically focus on reactor and fuel cycle technologies, storage and transportation, and disposal. These subcommittees have also held public meetings and will be reporting back to the full Commission recommendations for consideration.

[2] http://www.brc.gov/

The BRC issued a draft recommendation report on July 29, 2011[3]. These recommendations included long-term draft recommendations, several that require legislative and policy changes, and a set of near-term actions that can start the process while legislative changes are considered. The draft long-term recommendations are shown in figure 2 and grouped in programmatic areas that align with the FCT program missions. The third BRC recommendation addressing access to the nuclear waste fund is not listed as it is not within the FCT program scope.

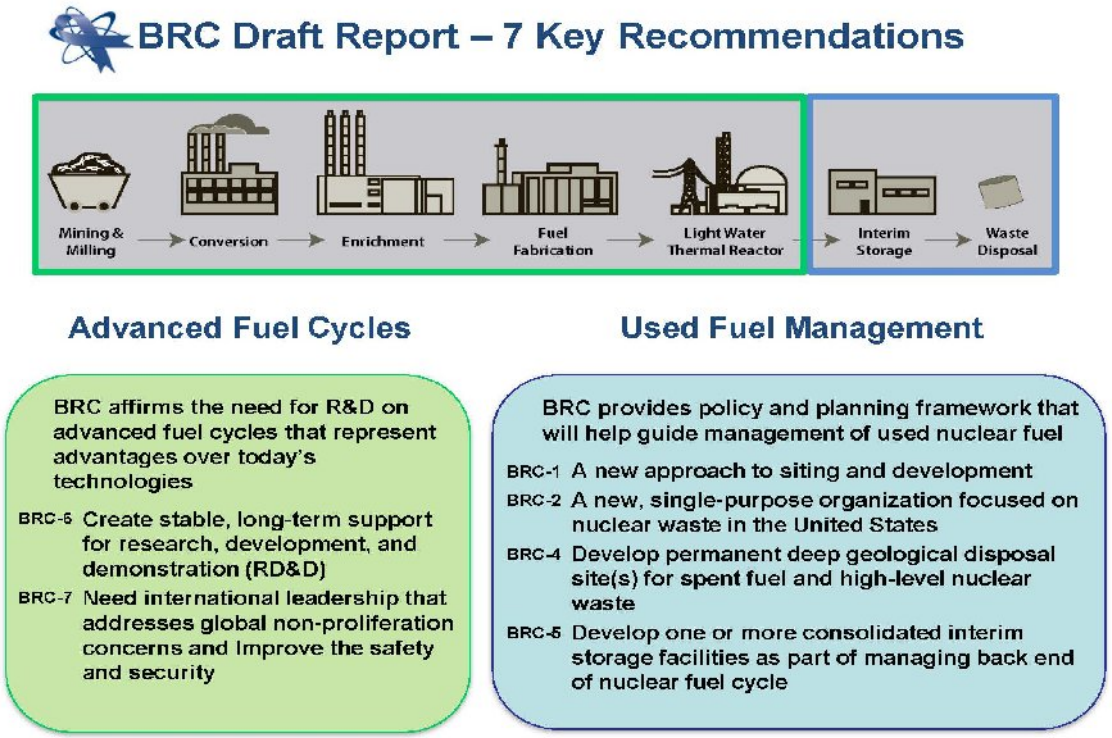

Figure 2 The Blue Ribbon Commission Draft Recommendations cover the spectrum of the Office of Fuel Cycle Technologies areas of focus.

Significant Congressional action will be required to develop a workable solution to the back end of the fuel cycle challenges. For now, DOE has no position on the draft report or its recommendations, but is formulating potential responses when the final report is issued in January 2012.

[3] http://brc.gov/sites/default/files/documents/brc_draft_report_29jul2011_0.pdf

Fukushima Daiichi

The events near the Fukushima Prefecture in Japan that began with an earth quake and tsunami on March 11, 2011, resulted in challenging the plant operations at the Fukushima Daiichi Nuclear Power Station. These events led to significant fuel failure, hydrogen generation, and explosions that spread contamination over a broad region. Coincident with this event, the FCT program had established a partnership with several industry teams to evaluate improved performance of light water reactor fuel concepts. The initial partnership was modestly funded (approximately $1 million) and included fuel and reactor vendors, utilities, and nuclear service providers. The fiscal year 2012 omnibus appropriations emphasized this area of work with an additional $19 million increase over the requested funds for advanced fuels research.

While it is recognized that current light water reactor fuel has been optimized over many years for economic, design-based operation, and is safe, secure and reliable. There exists extensive data and experience base with these fuel designs and associated materials during normal operation and accident conditions. Evolutionary advances in design, materials, chemistry, and operations have enabled the industry to very high fuel reliability. The events at Fukushima Dai-ichi suggest a need to consider a additional fuel concepts to enhance the tolerance to accident conditions in light water reactors. These concepts have now become the prime focus of the FCT program collaboration with industry partners.

Organizational Improvements

Two significant changes in the FCT program organization have taken place in the last two years that not only add scope, but also provide improved opportunities for integration of the technology being developed. The first occurred in the 2010 transition with the addition of the used fuel disposition research mission. This was a welcome supplement to the existing fuel cycle technologies as it allowed improved linkage with the various separations technology alternatives with differing isotopic combinations in different waste forms with the range of possible disposal geologies. There have also been advances in experience and disposal technologies since the 1980s, specifically in the area of designing and construction of a repository in a salt geology at the Waste Isolation Pilot Plant in New Mexico, and drilling and sealing technology applicable to deep borehole disposal concepts.

The second organizational change came in mid-2011 when the Uranium Management and Policy function was added to the FCT program. This addition strengthened the technology and policy analysis integration of existing "back end" options with uranium

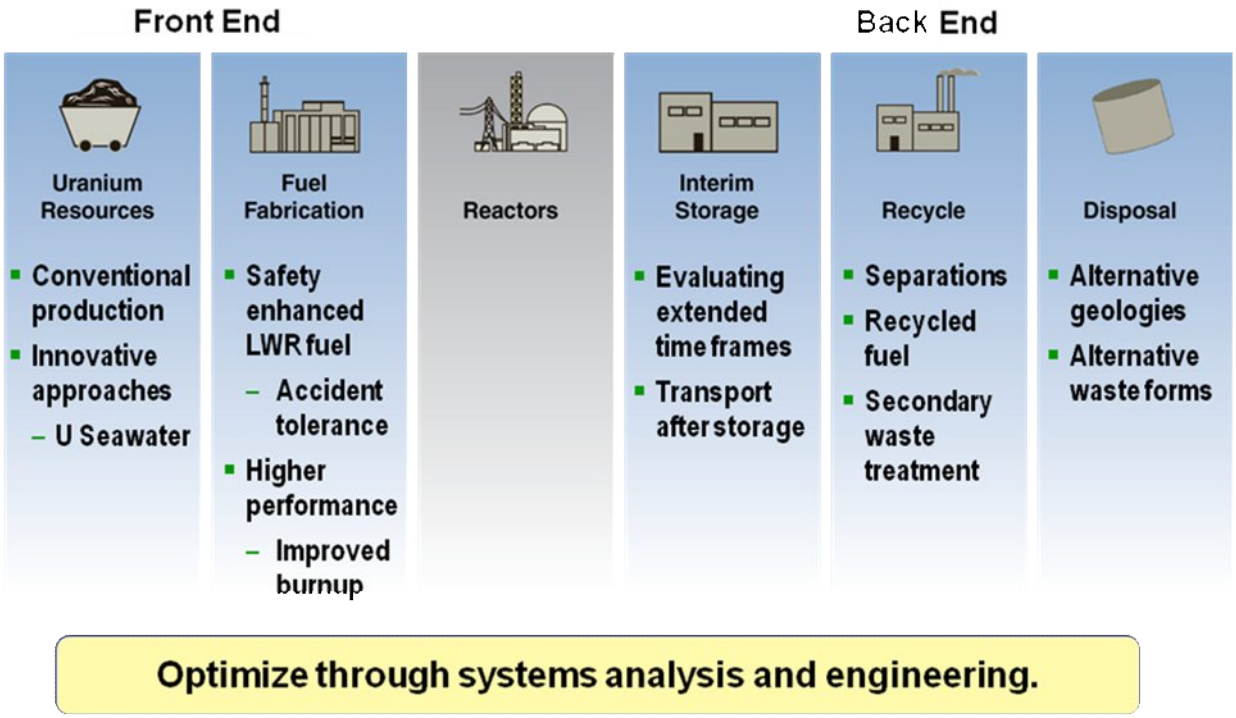

Figure 3 The Span of the Office of Fuel Cycle Technologies Scope with Summary Priorities

supply options in the "front end" of the fuel cycle. With this change the FCT program now spans the entire fuel cycle, noting that the integration with the advanced reactor technologies remain an essential link in any fuel cycle option considered. Figure 3 illustrates the span of FCT program technologies and summarizes program priorities.

PROGRAMMATIC PARTNERSHIPS AND COLLABORATIONS

Partnerships with industry, academia, and international organizations are essential to developing and evaluating sustainable fuel cycle options. A recent Government Accountability Office report on Fuel Cycle Option[4] addresses industry and international partnerships. The DOE January 2012 response to this report acknowledged these recommendations and indicated that work was in progress to improve partnerships and collaborations.

[4] http://www.gao.gov/new.items/d1270.pdf

Industry Collaboration

Industry collaborations are essential to the FCT program to ensure technologies under development can be commercialized. Commercialization must also consider the best interests of the U.S. and the access to affordable electricity and other forms of emerging energy technologies. The FCT primary means of partnering with industry is through a task order proposal contract establish through a solicitation with six industry teams. These teams reflect a diverse group of various roles in the nuclear market and are led by the following six companies: AREVA, CH2M Hill, ENERCON, EnergySolutions, GE Hitachi, and Shaw. It should be noted that there are four utilities participating through these industry teams (Duke Energy, Entergy, Exelon, and TVA).

Industry engagement also occurs through various levels of partnerships and collaborations with the DOE national laboratories. Challenges facing the FCT program partnerships with industry include both technical and programmatic (or policy) aspect of public-private engagement. An example of a technical challenge is the objective evaluation of various technology alternatives, advocated by various companies, and reconciling them with the best interest of the U.S. An example of a programmatic challenge is balancing the cost share between FCT and industry as technology matures and is commercialized (there is no common approach which leads to protracted negotiations and uncertain budgets and time frames). Clearly, the nuclear industry (both technology vendors, power utilities, and other users) play the most significant role in the nuclear market place. U.S. nuclear policy and the nuclear market will ultimately determine the timing and extent of any future fuel cycle technology deployment.

An important part of technology deployment and commercialization is ensuring predictable regulatory oversight. To address this, the FCT program is engaged with the Nuclear Regulatory Commission through an interagency agreement. This agreement allows NRC to provide the FCT program with regulatory insight on technologies of interest, thus avoiding any regulatory “dead ends” for approaches that may appear promising.

Because of the importance of developing technology with the intention of deployment in the commercial market place, the FCT program is continuing to seek better ways of addressing these challenges.

University Partnerships

Each FCT program budget request submitted to congress includes a 20 percent allocation of funds for the Nuclear Energy University Program (NEUP), where an annual cooperative agreement solicitation attracts a range of proposals from universities across the U.S. While awards of NEUP research projects are based on the quality of proposals and the relevance to FCT research priorities, some projects are better integrated with program priorities than others. A major focus in this area is to ensure all NEUP awards are well integrated with FCT program research priorities and that the results are tied directly into the expected FCT Program outcomes.

International Partnerships

The FCT program has established a variety of partnerships with international organizations. These partnerships differ in scope and complexity depending on the country, its capabilities and experience, and the congressional authorization for DOE to collaborate on sensitive nuclear information. Most partnerships are bilateral, but some multi-lateral arrangements exist (e.g., information exchanges with member countries of the Organization of Economic Development and Cooperation (OECD) through the OECD Nuclear Energy Agency).

While these partnerships and collaborations are essential to leveraging limited U.S. funding with resources of other nations, programmatic and budget uncertainties pose significant challenges to long-term commitments. The FCT program is continuing to develop plans for near-term collaborations while considering approaches to establish long-term arrangements with international partners that balance these uncertainties with the need for long-term commitments with tangible progress.

Partnerships with Other DOE Programs

The FCT program has made significant progress in establishing opportunities for collaboration with other DOE programs. This includes joint research on borosilicate glass waste forms with the Office of Environmental Management (EM), coordination on various on-line/in-line fissile material monitoring instrumentation for separations technologies with the National Nuclear Security Administration (NNSA), and understanding the science behind isolation performance of certain geologies with the Office of Science (SC). While these collaborations are making progress with good results, more can be done. FCT is taking steps to facilitate leveraging the constrained funds from each of these programs to achieve greater results on shared priorities.

Figure 4 The DOE Nuclear Separations Technologies Workshop, held July 27-28, 2011. was sponsored by EM, NE, and NNSA with action SC participation.

An example of this is the effort started in July 2011 when a nuclear separations technologies workshop (see figure 4) was sponsored by EM, NE, and NNSA (SC was also an active participant in the workshop). This workshop started the process of

developing a DOE roadmap on separations technologies that benefit all DOE programs and establishing a separations center of knowledge that can facilitate information sharing and collaborations between researchers in this area. This effort will also identify opportunities for joint demonstrations and the scale-up of maturing technologies (where program costs are typically substantial).

CONCLUSION

The FCT program is making progress in implanting a science based, engineering driven research and development program that is evaluating options for a sustainable fuel cycle in the U.S. Responding to the BRC recommendations, any resulting legislative changes, and meeting the needs of the commercial nuclear industry (including developing and evaluating fuel concepts that may enhance accident tolerance in light water reactors while possibly improving fuel performance) are program priorities. Continuing to build partnerships and collaborations with industry, universities, international organizations, and other DOE programs are essential to addressing the challenges facing the FCT program.

REFERENCES

1. Department of Energy, Nuclear Energy Research and Development Roadmap, April 2010, http://nuclear.energy.gov/pdfFiles/NuclearEnergy_Roadmap_Final.pdf

2. Blue Ribbon Commission on America's Nuclear Future web site, http://www.brc.gov/

3. Blue Ribbon Commission on America's Nuclear Future Draft Report to the Secretary of Energy, July 29, 2011, http://brc.gov/sites/default/files/documents/brc_draft_report_29jul2011_0.pdf

4. Nuclear Fuel Cycle Options - DOE Needs to Enhance Planning for Technology Assessment and Collaboration with Industry and Other Countries, October 2011, [1] http://www.gao.gov/new.items/d1270.pdf

5. The DOE Nuclear Separations Technologies Workshop Report, July 27-28, 2011, (http://events.energetics.com/NuclearSeparationsTechnologyWorkshop/documents.html)